A Mass Inshore Movement of Fishes on the Florida Coast

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Sporadic mass shoreward movement of marine fishes and other animals is a fairly frequent phenomenon in certain parts of the world. Periodic fish kills have been reported from Walvis Bay, Southwest Africa (Copenhagen, 1953), and from Concepcion Bay, Chile (Falke, 1950). At both places these kills occur under specific meteorologic and oceanographic conditions, which are coupled with the geography of the region concerned. In United States waters such movements are best known from Mobile Bay, Alabama (Loesch, 1960), where, in contrast to the situations in Africa and South America, mortality is infrequent. Although these movements are not common, they are by no means unusual; from 1946 to 1956, inclusive, 35 such occurrences were reported from Mobile Bay, varying in number from none in 1954 to ten in 1950. This phenomenon is locally termed a "Jubilee" or "Alabama Jubilee", and when it occurs local residents congregate in large numbers to gather the animals so affected.

Large congregations of freshwater fishes have also occasionally been observed, in which neither spawning activity nor obvious physical barriers to migration appear to be involved. One such concentration, which occurred in a small stream near Gainesville, Florida, was investigated in March, 1963. Although the fishes were gathered in large numbers at the water's edge, they otherwise did not appear to be in distress, and chemical analysis of the water failed to indicate anything abnormal.

At about 3:00 on the afternoon of 17 September 1962, a spectacular concentration of fishes was noted along the beach just south of Marineland, Florida, which is situated about 50 miles south of Jacksonville. This beach, which is composed basically of the quartz sand characteristic of the Florida upper east coast, contains a large concentration of coquina rocks at or near the water line, which, in turn, afford a favorable habitat for certain species of shore fishes. Although many fishes were found above the water line, most of the eels so stranded remained in their burrows and were still alive. What mortality had occurred apparently was due solely to prolonged exposure to the air, since those individuals still in the water did not appear to be in distress. A high percent-

age of the species involved usually live beyond the intertidal area (one species occurring as deep as 1500 feet), whereas others may live in shallow water but rarely are found in the ecological situation prevailing at Marineland beach. Furthermore, with one exception the presumed non-resident species are burrowers, and belong to only three families (Bothidae, Ophidiidae, and Ophichthidae).

Inasmuch as a "jubilee" has not, to my knowledge, previously been reported in the literature from the Atlantic coast of the United States, the surrounding circumstances seem worthy of discussion. The prevailing meteorologic and oceanographic conditions during the Marineland and Mobile Bay jubilees are compared and are shown, for the most part, to be quite different. Although the causes of the Mobile Bay jubilees seem to be well understood, more information is needed before the Marineland phenomenon can be adequately explained. The usual habitats of the fishes collected at Marineland also are discussed, and an attempt is made to correlate these with possible movements of the various species.

Loesch (1960) presented a detailed discussion of mass shoreward movements of fishes and crustaceans in Mobile Bay. He showed that such movements occur as the result of a definite combination of conditions, which results in an inshore movement of water that is low in dissolved oxygen and which forces the animals ahead of it. He found that jubilees occur: 1) only in summer; 2) usually before sunrise; 3) usually when the wind on the previous day and during the jubilee is from an easterly direction (a change in wind direction will cause the jubilee to cease); 4) only on a rising tide (a change to a falling tide will stop the jubilee); and 5) when two water masses meet, with the saltier water invading during the jubilee. In addition, the concentration of fishes and invertebrates during a jubilee usually is on the east side of the bay; however, Dr. Herbert Boschung informs me that this may occasionally occur on the opposite shore. Presumably a west-shore jubilee results from the same combination of conditions described below, except that the wind direction is reversed.

Loesch determined that a jubilee results from the following sequence of events. A pocket of highly saline water is present in the deepest area of Mobile Bay, and this pocket is overlain by fresh water entering the bay from the Alabama River. In summer the heavier, salty water tends to lose oxygen and gain carbon

dioxide, from the combination of high temperature and accumulated organic debris. During the day plant life in this pocket of water produces oxygen and uses carbon dioxide, but at night this process is reversed. Normally, the oxygen-poor water remains in the deepest part of the bay; however, a gentle east wind, though of insufficient intensity to mix the water near shore, is nevertheless strong enough to push the surface water west and offshore. As the water moves offshore, it is replaced by the deeper, more saline water, which is pushed shoreward by a rising tide. When, under the conditions of east wind and rising tide, this body of deeper, oxygen-poor water moves very close to shore, the demersal animals crowd to the shore and a jubilee is in progress.

The concentration of fishes observed at Marineland differs from those from Mobile Bay in a number of ways. First, it occurred during the middle of the afternoon. Second, according to the tidal charts (U. S. Coast and Geodetic Survey, 1962), high tide around Marineland on 17 September 1962 occurred about 10:30 AM and low tide about 5:00 PM. Although these times are approximate for the Marineland area, the tide nevertheless was falling there around 3:00 PM. Third, the area where the jubilee was observed is not partially enclosed by land, as is Mobile Bay. Fourth, the jubilee does not seem to have been confined to the immediate area around Marineland, but was noted by John Taylor on the same afternoon just above Matanzas Inlet, about 4 miles to the north. Fifth, no unusual concentration of invertebrates was observed, except as noted below. Sixth, there are no major freshwater streams entering the ocean around Marineland and thus there is no meeting of large salt and fresh water masses. Seventh, no large quantity of organic debris, such as is present in Mobile Bay, is believed to be present off Marineland. Wind direction on the afternoon in question was not noted, although the day was very calm, and what wind there was presumably was blowing in from the ocean, i.e., from an easterly direction.

The only unusual invertebrates encountered were pteropod mollusks (Gastropoda: Opisthobranchia), which were present in great numbers, not only at Marineland, but at least as far away as the St. Johns River, about 50 miles to the north (Ted Allen, in litt. to F. J. S. Maturo). Pteropods are pelagic, and sometimes are found in tremendous numbers along beaches in different parts of the world

(Abbott, 1954, p. 292). As mentioned previously, the species of fishes believed to have moved into shore at Marineland are all demersal, as are those species involved in the jubilees in Mobile Bay. Although there may be a direct relationship between the unusual concentrations of pteropods and fishes, the ecological differences between these animals suggest that the two phenomena possibly are coincidental.

F. G. Wood, at the time Curator of Exhibits at Marine Studios, told me that he had seen only one other jubilee in the Marineland area, this having taken place during late summer of 1956. He said that the weather at the time had been hot and the seas very calm for several weeks previously; these conditions had also prevailed during early September, 1962. Thus, except for the similarity in wind direction, which in this case is probably coincidental, the only really basic similarities between the Marineland and Mobile Bay jubilees are the facts that all occurred during the summer and that the fishes involved are bottom dwellers.

Frederick H. Berry has suggested that the jubilee might possibly be the result of deep (175-200 fathoms) subsurface waves over the slope zone off northeastern Florida. However, Paul Struhsaker, who has studied these waves, doubts that these phenomena are related. Struhsaker has also analyzed the bottom temperature data taken during the cruises of the research vessel *Theodore N. Gill* along the southeastern Atlantic coast, and he informs me (in litt.) that he can find no evidence of any conditions during late summer that might account for the jubilee.

The following points, then, can be made. 1) The fact that the two jubilees observed in the Marineland area both occurred during late summer, following a period of hot, calm weather seems significant. 2) In all likelihood the Marineland jubilees resulted from a chain of as yet undetermined events that were triggered by the prevailing weather conditions. 3) Possibly the fish (and pteropods?) were driven toward shore by an oxygen-poor, carbon-dioxide rich water mass, of undetermined origin, moving inshore from deeper water. But if so, 4) the apparent absence of any unusual concentration of bottom-dwelling invertebrates is puzzling. A satisfactory explanation for these phenomena is yet to be found.

Inasmuch as the fishes obtained during the jubilee included a

mixture of resident and non-resident forms, a review and discussion of the various species encountered seems pertinent.

I. Resident forms commonly encountered over an open bottom:

Trachinotus carolinus (Linnaeus)
Trachinotus falcatus (Linnaeus)
Menticirrhus littoralis (Holbrook)
Umbrina coroides Cuvier
Eucinostomus argenteus Baird

II. Resident species inhabiting rocky shore, frequently in intertidal areas:

Centropristis striatus striatus (Linnaeus) (young only)
Rypticus maculatus Holbrook (young only)
Anisotremus surinamensis (Bloch) (young only)
Scorpaena plumieri Bloch (young only)
Abudefduf saxatilis (Linnaeus) (young only)
Abudefduf taurus (Müller and Troschel) (young only)
Labrisomus nuchipinnis (Quoy and Gaimard)
Hypleurochilus geminatus (Wood)
Hypsoblennius hentz (Lesueur)
Gobiesox strumosus Cope

The presence of young only of the first six species above probably is related to the lack of living space for adults, as well as the fact that spawning likely occurred offshore, and the eggs, or young, later drifted in and were deposited among the rocks. In some cases spawning may have occurred well to the south, and the eggs or young were carried north by the Gulf Stream. These species are free swimming, and, with the possible exception of *Abudefduf*, probably move offshore as they reach a larger size. Except for *Centropristis striatus*, all continue to live in rock or reef areas as adults.

The last four species never swim free of the rocky substrate, and, as a result, spend their postlarval life in a very limited area. All are found in shallow situations, and seldom occur in water much deeper than 10 or 20 feet. The populations of *Labrisomus nuchipinnis*, *Hypleurochilus geminatus*, and *Hypsoblennius hentz*, however, could be a mixture of resident and immigrant individuals, inasmuch as these species have pelagic larvae. *Gobiesox strumosus* does not have pelagic larvae, and is the species least likely to be affected by recruitment from the outside. It is unlikely that any

of these four species move through open areas after having passed the larval stage.

A subsequent collection at the Marineland locality the following summer failed to turn up *Anisotremus surinamensis* or *Rypticus maculatus;* however, inasmuch as two other species (*Lutjanus griseus* and *Diplodus holbrooki*) not taken in the September, 1962, collection were found, this may not be meaningful. Although Courtenay (1967, p. 274) reports that most specimens of *Rypticus maculatus* he examined were collected at depths of from 15-50 fathoms, I have found this species to be fairly common within a few feet of shore around Anna Maria Island, Manatee County, Florida, in the eastern Gulf of Mexico (UF 10888, 10905, 10942; a total of 15 specimens, collected in July, 1963).

III. Probable non-resident species, thought to have moved in from deeper water:

Centropristis philadelphicus (Linnaeus)
Ophidion grayi (Fowler)
Rissola marginata (DeKay)
Syacium papillosum (Linnaeus)
Citharichthys spilopterus Günther
Etropus microstomus (Gill)
Ophichthus ocellatus (Lesueur)
Ophichthus gomesi (Castelnau)
Ophichthus melanoporus Kanazawa
Letharchus velifer Goode and Bean
Bascanichthys scuticaris (Goode and Bean)

With one exception, all of the above species are frequently encountered in shallow water, and perhaps are more common in close to shore than is generally realized. The species of Ophidiidae (genera *Ophidion* and *Rissola*) and Ophichthidae (genera *Ophichthus, Letharchus,* and *Bascanichthys*) live in the substrate and come out into the open only at night (Starck and Davis, 1966, pp. 317 and 342; and personal observation), with the cusk eels (ophidiids), in particular, moving free of the burrow. The snake eels (ophicthids) burrow well down into the substrate, and this, in company with their slender bodies, probably accounts for their relative scarcity in trawl collections. The geographic and bathymetric distributions of many species of Ophichthidae is consequently poorly known. The use of rotenone poisons has resulted

in sizeable collections of certain species (e.g., *Bascanichthys scuticaris*) occurring in very shallow water. This would suggest that many of the deep-water species probably are more common than collections indicate. Although the ophidiids and flatfishes live in the substrate, they do not live in deep burrows, as do the ophichthids; consequently, they are much more easily collected by trawls and dredges.

Of the above species, the only ones with which I have had extensive experience are *Citharichthys spilopterus* (family Bothidae) and *Bascanichthys scuticaris* (family Ophicthidae). The former is very common in estuarine situations, and frequently is found in completely fresh water. The latter is common around Cedar Key, Florida, on the Gulf coast, where it occurs in oyster beds or in closely similar situations in water a few inches deep.

The record of *Ophichthus melanoporus* is easily the most interesting and significant of those listed above. This species was described by Kanazawa (1963) from five specimens taken at a depth of 250 fathoms off Andros Island (Bahamas) at COMBAT station 448. The present record, which is the first for United States waters, suggests that the single specimen either is a stray from deeper water, or that the geographic and bathymetric distribution of the species is much more extensive than is presently realized. In view of our imperfect knowledge of the distribution of many species of Ophichthidae, the latter possibility certainly cannot be ignored. Nevertheless, if *O. melanoporus* should occur regularly within several hundred feet of the surface along the east coast of Florida, it is surprising that the species has never been found in the hundreds of collections made at various depths from this area.

The specimen of *Ophichthus melanoporus* was collected by John Taylor on the beach just north of Matanzas Inlet, under the same conditions described for the Marineland locality. Several other eel specimens also given to me by Mr. Taylor are of the same species found at Marineland. Inasmuch as Matanzas Inlet is only a short distance away and the ecological conditions were the same as those encountered at Marineland, the specimen of *O. melanoporus* is discussed concurrently with those taken at the latter locality.

Several subsequent rotenone collections at the site of the jubilee, both in and around the coquina rocks as well as over the open sand

bottom, failed to reveal any flatfish, cusk-eels, or snake eels. Although this does not necessarily mean that these fish were not present there at the time the collections were made, it nevertheless is suggestive. Furthermore, the habitat from which *Bascanichthys scuticaris* was collected in the eastern Gulf of Mexico is somewhat different from that encountered at Marineland. Finally, the collection of the specimen of *Ophichthus melanoporus,* which otherwise has been found only in 250 fathoms of water, further indicates that some movement into shallow water has occurred.

ACKNOWLEDGEMENTS

I wish to thank the following individuals: Dr. C. Richard Robins, Institute of Marine Science, University of Miami, for identifying some of the cusk-eels (ophidiids) reported upon and for reviewing and commenting upon this manuscript; Frederick H. Berry, Tropical Atlantic Biological Laboratory, U. S. Fish and Wildlife Service, Miami, Florida, and Paul Struhsaker, University of Hawaii (formerly U. S. Fish and Wildlife Service, Brunswick, Georgia), for comments relating to possible causes of the Marineland jubilee; Dr. Archie F. Carr, University of Florida, for reviewing this manuscript; Dr. E. Lowe Pierce, University of Florida, for information on tidal changes on the east coast of Florida and also for reviewing this manuscript; Dr. F. J. S. Maturo, University of Florida, for information on the pteropods encountered during the jubilee; John Taylor, U. S. Fish and Wildlife Service, St. Petersburg Beach, Florida, for the donation of several eel specimens collected during the jubilee at Matanzas Inlet and for information pertaining to this collection; F. G. Wood, Jr., U. S. Naval Missile Center, Point Mugu, California (formerly of Marine Studios, Marineland), for information on previous Marineland jubilees; and Dr. Herbert T. Boschung, Jr., University of Alabama, for additional information on the Mobile Bay jubilees.

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Quart. Jour. Florida Acad. Sci. 31(1) 1968(1969)